

WHAT IS CLAIMED IS:

1. A method for synthesizing noise in a digital image comprised of a plurality of color channels, where the noise is used to represent a synthetic texture that visually approximates a predetermined appearance, said method comprising the steps of:

(a) estimating noise statistics based on a set of spatial autocorrelation coefficients and a set of spectral correlation coefficients that correspond to the color channels, where at least one of the spatial autocorrelation coefficients is weighted by at least one of the spectral correlation coefficients, thereby providing a weighted set of autocorrelation coefficients, and where filter coefficients are obtained from the weighted set of autocorrelation coefficients; and

(b) synthesizing a synthetic texture by using the filter coefficients to filter a random noise field in each of the color channels, thereby producing output noise fields in each of the color channels that replicate the synthetic texture when combined into the digital image.

2. The method as claimed in claim 1 wherein the step (b) of synthesizing a synthetic texture comprises producing a filtered noise field in each of the channels and weighting at least one of the filtered noise fields with a portion of another filtered noise field to produce at least one of the output noise fields.

3. The method as claimed in claim 1 wherein the noise statistics estimated in step (a) are based on a set of spatial autocorrelation coefficients and a set of spectral correlation coefficients obtained from an arbitrary source.

4. The method as claimed in claim 3 wherein the arbitrary source is obtained from a plurality of predetermined media "looks" or appearances.

5. The method as claimed in claim 3 wherein the arbitrary source is originated from user interaction.

6. The method as claimed in claim 1 wherein the digital image comprises a sequence of digital images and the noise statistics estimated in step (a) are based on a set of spatial autocorrelation coefficients and a set of spectral correlation coefficients obtained from an analysis of the sequence of digital images.

7. The method as claimed in claim 6 wherein the analysis of the sequence of digital images comprises the steps of motion compensated filtering of the sequence of digital images, thereby providing filtered images, and operation on the filtered images with a noise estimation algorithm to provide the noise statistics.

8. The method as claimed in claim 7 further comprising the step of spatially masking the filtered images to identify preferred images areas for noise estimation.

9. The method as claimed in claim 1 wherein the digital image comprises a sequence of source images and another sequence of target images, and wherein the statistics estimated in step (a) are based on a set of spatial autocorrelation coefficients and a set of spectral correlation coefficients obtained from analyzing and matching the source images and the target images.

10. The method as claimed in claim 1 wherein the digital image comprises a first sequence of images and a second sequence of images, each with a different source noise level, and wherein the statistics estimated in step (a) are obtained for each sequence of images by motion filtering of each sequence, thereby providing filtered images in each sequence, and operation on the filtered images in each sequence with a noise estimation algorithm to provide the noise statistics, wherein the noise statistics in each sequence are adjusted to a similar

target noise level, whereby the output noise field added to each sequence will be different but the final noise positions of the sequences will be the same.

11. The method as claimed in claim 1 wherein the synthetic texture visually approximates a desired grain appearance.

12. A method for generating filter coefficients for use in noise synthesis from a multi-channel source of noise data, said method comprising the steps of:

(a) providing a set of target autocorrelation function (ACF) values for one or more signal levels for each channel of the multi-channel noise data and a set of target spectral correlations for the multi-channel noise data;

(b) modifying the target ACF values using the target spectral correlation coefficients to produce a set of modified ACF values; and

(c) generating filter coefficient values for the filter coefficients from an optimization algorithm by using the modified ACF values to solve an optimization problem defined by the optimization algorithm.

13. The method as claimed in claim 12 wherein a noise table is used in step (a) to specify the variance of the one or more signal levels for each channel of the multi-channel noise data.

14. The method as claimed in claim 12 wherein the filter coefficients generated in step (c) are used to modify the noise characteristics of a multi-channel digital image signal, said method further comprising the steps of:

(d) providing a random noise field in each of the channel;

(e) using the filter coefficients to filter each random noise field in each channel, thereby producing a plurality of filtered noise fields;

(f) weighting one or more of the filtered noise fields, thereby producing final noise fields in each of the signal channels; and

(g) adding the final noise fields to the channels of the digital image signal.

15. The method as claimed in claim 14 wherein the noise fields provided in step (d) have a variance that is a function of the digital image signal.

16. A method for generating noise that visually approximates a desired appearance when added to a multi-channel digital image, where the noise is synthesized from a multi-channel source of noise data, said method comprising the steps of:

(a) providing a set of target autocorrelation function (ACF) values for one or more signal levels for each channel of the multi-channel noise data and a set of target spectral correlations for the multi-channel noise data;

(b) modifying the target ACF values using the desired spectral correlation coefficients to produce a set of modified ACF values;

(c) generating filter coefficient values for the filter coefficients from an optimization algorithm by using the modified ACF values to solve an optimization problem defined by the optimization algorithm

(d) using the filter coefficients to filter a random noise field provided in each signal channel, thereby producing a plurality of filtered noise fields;

(e) weighting one or more of the filtered noise fields, thereby producing final noise fields in each of the signal channels; and

(f) adding the final noise fields to the channels of the digital image signal.

17. The method as claimed in claim 16 wherein a noise table is used in step (a) to specify the variance of the one or more signal levels for each channel of the multi-channel noise data.

18. The method as claimed in claim 16 wherein the random noise fields provided in step (d) have a variance that is a function of the digital image signal.

19. The method as claimed in claim 16 wherein the weighting of one or more of the filtered noise fields in step (e) comprises weighting a filtered noise field in one channel with a portion of another filtered noise field from another channel.

20. The method as claimed in claim 16 wherein the desired appearance being approximated comprises the appearance of a predetermined film grain.

21. A method for estimating the noise statistics in an image sequence comprising a plurality of source image frames, said method comprising the steps of:

(a) finding a correspondence between the source image frames in the image sequence based on motion estimates between the frames;

(b) using a motion-compensated filter to generate an estimate for one or more noise free image frames in the image sequence;

(c) using the difference of the noise free image frames and the source image frames to create noise image data for a noise image frame;

(d) iterating the noise image data back through the motion-compensated filter to improve the noise image data and the noise image frame; and

(e) using the noise image frame from step (d) to compute noise statistics.

22. The method as claimed in claim 21 further comprising the steps of:

(f) generating a spatial mask using at least one of the source image, the filtered image and the noise image, said mask being used to identify candidate regions within the source image frames with valid noise estimates; and

(g) using the identified candidate regions from step (f) in combination with step (e) to compute noise statistics.

23. A method for matching noise between a source and target digital image, where the noise is synthesized from a multi-channel source of noise data, said method comprising the steps of:

(a) providing a set of source and target autocorrelation function (ACF) values for one or more signal levels for each channel of the multi-channel noise data and a set of source and target spectral correlations for the multi-channel noise data;

(b) modifying the source and target ACF values using the source and target correlation coefficients to produce a set of modified ACF values;

(c) generating filter coefficient values for the filter coefficients from an optimization algorithm by using the modified ACF values to solve an optimization problem defined by the optimization algorithm

(d) using the filter coefficients to filter a random noise field provided in each signal channel, thereby producing a plurality of filtered noise fields;

(e) weighting one or more of the filtered noise fields, thereby producing final noise fields in each of the signal channels; and

(f) adding the final noise fields to the channels of the digital image signal to produce an image having noise statistics of the target image.

24. A system for synthesizing noise in a digital image comprised of a plurality of color channels, where said noise is used to represent a synthetic texture that visually approximates a predetermined appearance, said system comprising:

(a) a noise estimation stage for estimating noise statistics based on a set of spatial autocorrelation coefficients and a set of spectral correlation coefficients that correspond to the color channels, where at least one of the spatial autocorrelation coefficients is weighted by at least one of the spectral correlation coefficients, thereby providing a weighted set of autocorrelation coefficients, and where a set of filter coefficients are obtained from the weighted set of autocorrelation coefficients; and

(b) a noise synthesis stage for synthesizing a synthetic texture by using the filter coefficients to filter a random noise field in each of the color channels, thereby producing output noise fields in each of the color channels that replicate the synthetic texture when combined into the digital image.

25. The system as claimed in claim 24 wherein the noise synthesis stage produces a filtered noise field in each of the channels and weights at least one of the filtered noise fields with a portion of another filtered noise field to produce at least one of the output noise fields.

26. The system as claimed in claim 24 wherein the noise statistics estimated by the noise estimation stage are based on a set of spatial autocorrelation coefficients and a set of spectral correlation coefficients obtained from an arbitrary source.

27. The system as claimed in claim 26 wherein the arbitrary source is obtained from a plurality of predetermined media “looks” or appearances.

28. The system as claimed in claim 26 wherein the arbitrary source is originated from user interaction.

29. The system as claimed in claim 24 wherein the digital image comprises a sequence of digital images and the noise statistics estimated by the noise estimation stage are based on a set of spatial autocorrelation coefficients and a set of spectral correlation coefficients obtained from an analysis of the sequence of digital images.

30. The system as claimed in claim 29 wherein the noise estimation stage includes a filter for motion compensated filtering of the sequence of digital images, thereby providing filtered images, and a noise estimation algorithm for operating on the filtered images to provide the noise statistics.

31. The system as claimed in claim 24 wherein the noise estimation stage further includes an algorithm for spatially masking the filtered images to identify preferred images areas for noise estimation.

32. The system as claimed in claim 24 wherein the digital image comprises a sequence of source images and another sequence of target images, and wherein the statistics estimated by the noise estimation stage are based on a set of spatial autocorrelation coefficients and a set of spectral correlation coefficients obtained from analyzing and matching the source images and the target images.

33. The system as claimed in claim 24 wherein the digital image comprises a first sequence of images and a second sequence of images, and wherein the statistics estimated by the noise estimation stage are obtained for each sequence of images by motion filtering of each sequence, thereby providing filtered images in each sequence, and operation on the filtered images in each sequence with a noise estimation algorithm to provide the noise statistics, wherein the noise statistics in each sequence are adjusted to a similar target noise level.